Factors that Affect Support for Rain Gardens in Columbus, Ohio

<u>Honors Thesis</u>

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Abstract

The Blueprint Columbus project was created as a response to stormwater runoff issues the city of Columbus, Ohio was faced with. One of the four methods Blueprint Columbus uses to address these problems is green infrastructure, more specifically, rain gardens. When construction began there was a wide range of opinions on the project. This research studied the degree to which being (1) informed about the program, (2) involved in the planning process, and (3) knowledgeable about water quality problems affect support for rain gardens in the neighborhood of Clintonville. It was found that all three have a positive association with support for the raingardens. This study adds to the small but growing body of research on the topic by providing a quantitative assessment as well as providing the unique context that is Columbus, Ohio.

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Introduction

From Oregon to New York, stormwater runoff has been a challenge for cities to solve. This issue becomes even more salient as the existing infrastructure continues to age allowing for less efficiency, and even bigger problems aside from flooded streets. The plants, animals, and nearby ecosystems are impacted as well because the runoff was delivering pollution directly to the neighboring streams. Blueprint Columbus, as discussed later in this paper, was a project created to address this very problem. However, due to the fact that this project includes a massive infrastructure program that affects thousands of residents across multiple projects, it is important for its implementation *and* continued support if the project is to be viewed in a positive light. This study is an effort to understand and explain whether and to what degree the perception that residents felt informed and involved about the Blueprint program, and whether self-reported knowledge of local water quality problems explain support for this program in Columbus, Ohio.

There has been increased emphasis on engagement with residents and citizens when it comes to environmental planning and decision-making in recent decades. This emphasis is based on the assumption that outreach programs that inform and involve citizens produce better outcomes. Wiliker et al., in their research on citizen participation, state that “active stakeholder participation leads to *legitimate* and *informed* future planning that accounts for society’s needs,” after their investigation into six different green infrastructure investments called *Improving Participation in Green Infrastructure Planning* (2016). Wiliker et al.’s work also uncovered something that stakeholders, themselves, were beginning to understand: a one size fits all involvement strategy such as mailed reports, city meetings, round tables, and opinion surveys, alone, was not adequate for most cities’ projects. Although the surveyed stakeholders felt they were adequately involved in their projects and rated the classical approaches positively, they still “desired a broader and more tailored mix of approaches” such as including more social media channels, 3D visualizations, interactive workshops, and the ability to provide input during not just implementation but the earliest portions of the design processes as well. (Wiliker et al., 2016). This desire for a more customized approach was felt even in positive outcome scenarios. In less successful outcomes, it was observed that those in charge of such outreach programs “frequently do not have a good understanding of how to design participation processes to achieve desirable outcomes” (Bryson, Quick, & Slotterback, 2012, p. 23). This lack of knowledge about how to design participation and engagement processes may be due to the fact that there has been a lack of quantitative work on public perceptions of green infrastructure programs (Yang & Pandey, 2011).

The World Bank defines participation as “a process through which stakeholders influence and share control over development initiatives and the decision and resources which affect them (World Bank, 1996, p. xi). Many researchers call for efficient local stakeholder participation in regard to green infrastructure due to its inherent societal benefits and physical impacts on the surrounding areas (Mackrodt & Helbrecht, 2013). For clarification, the European Commission (2013) defines green infrastructure (GI) as, “a strategically planned network of high-quality natural and semi-natural areas that include other environmental features and is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings”. Wiliker et al. (2016) adds on to this approach noting that green infrastructure is not just a strategic planning concept, but that it is also an implementation approach, and should be addressed with a bottom-up perspective. However, implementing a bottom-up approach is not nearly as easy as it seems. The main difficulty lies in the struggle between creating “pseudo-participation” and giving the stakeholders real power in the design and implementation process of the project (Arnsetin, 1969).

The gradations between non-participation and real participation were classified by Sherry Arnstein in 1969. She created the Arnstein Ladder, which is a typology of eight different levels of participation, with the bottom rung (manipulation) being the nonparticipation end of the scale and the top rung (citizen control) representing total citizen power over an issue (Arnstein, 1969). The groupings that are the most important for this study are the Informing, Consultation, and Partnership rungs of the ladder (See Figure 1). In regard to Informing, Arnstein states that, "informing citizens can be the most important first step toward legitimate citizen participation," but she warns about the common issue of "one-way flow of information" (1969, p. 219). Arnstein describes Consultation as "inviting citizens opinions… but if consulting them is not combined with other modes of participation, this rung of the ladder is still a sham" (1969, p. 216). She expresses that in order for this rung to deliver real participation, project leaders must place importance on citizen's concerns, opinions, and ideas in order to assure this feedback will be taken into account (1969, p. 216). Attitude surveys are one of the most popular methods for Consultation (Arnstein, 1969). Lastly, Arntstein suggests that Partnership is the rung where a redistribution of power occurs between the stakeholder and powerholders, with both parties obtaining a share of planning and decision making (1969). Because stakeholders have more power within a project, they have a greater ability to ensure their needs are being met. All three of these rungs are important when it comes to citizen participation, but they can produce different levels of involvement and support.

Similar to the Partnership rung of Arnstein's ladder is the concept of performative participation (Turnhout et al., 2010; Mackrodt & Helbrecht, 2013). Performative participation is seen as useful for green infrastructure projects as it is characterized by a focus on: "materiality, audience orientation, implementing on the ground, and joint designing" (Wiliker et al., 2016, p. 233). This involvement and open dialogue between planners and other stakeholders, if they are engaged, is observed to have better outcomes and conditions, including smoother installation and more practical implementation methods (Wiliker et al., 2016). This high degree of involvement is crucial for higher levels of support as Wiliker et al. states: "…it allows stakeholders to shape the project and feel a sense of responsibility and increases acceptance while providing planners with justifications for their activities." (2016, p. 246).

Another factor that increases a community's level of participation and support of green infrastructure is knowledge of water quality problems, climate change, and the role green infrastructure plays in abating the two. In many communities and case studies, fundamental knowledge issues present themselves as a huge hurdle for green infrastructure implementation and support. For example, in the study published by Barnhill and Smardon (2012, p. 6), focusing on the area of Syracuse, New York, they noted that, "respondents displayed confusion about what ecosystem services are, as well as what GI is," which then translated to the residents not understanding what the benefits of implementation are either. Everett's review of the published literature of sustainable drainage systems notes that a majority of residents in GI areas, do not understand why this type of infrastructure is implemented (2017). Because of this lack of knowledge, several studies have concluded that a majority of residents, would choose gray infrastructure rather than green, based on perceptions instead of actual knowledge (Everett, 2017).

However, something like "knowledge" is difficult to test for and analyze across studies because some researchers ask the respondents what they think their level of knowledge is versus other researchers actually testing respondents to form a knowledge baseline. The research done by Baptiste et al. (2015, p. 2) explains that some of this variation is due to the fact that, "few [studies] outline processes for gauging neighborhood public perceptions regarding green infrastructure knowledge and receptivity toward individual property or neighborhood implementation of GI projects." Due to this lack of standardization and quantitative studies, it is more difficult to get a clear view on how knowledge quantitatively affects the levels of support for green infrastructure.

Yet, just as a lack of knowledge of water quality problems can be problematic for garnering community support, when there is a high level of knowledge of water quality problems, it generally increases the participation and support for GI, as seen in the following studies. Baptiste et al. (2015) researched the Syracuse area three years after the Barnhill and Smardon study and after a countywide stormwater information initiative was completed. The Baptiste et al. study showed that a high level of water quality knowledge was correlated to a high level of personal efficacy to address the problem, which in turn led to the higher rates of support and willingness to implement GI in their communities. Another study found that knowledge of water quality issues can increase support for GI because if residents understand the problem affecting them and their role in the solution, they are more likely to feel that GI contributes to their lives in a positive way and are more likely to support implementation and continued upkeep of the projects (Everett, 2017).

The body of research around the effect residents have on GI is limited but growing (Barnhill and Smardon, 2012). When looking at studies conducted in the United States, few are based specifically on rain gardens, as the majority are focused on the idea of GI as whole (Everett, 2017). Yang and Pandey note in their work regarding citizen participation theories, "as a step forward, yet it is important to test theories across situations and mechanisms. The impact may be context and issue specific, but there is reason to expect general patterns across contexts and issues" (2012, p. 881).

As the studies above show, in order for the implementation and upkeep of rain gardens to be successful, they must have the backing of the public. There are numerous different factors that affect the support of rain gardens that can occur at any point of the process. The introduction of the Blueprint Columbus rain garden projects gives us a unique context to study the effects of three different variables on levels of support for rain gardens. Residents, even those who lived on the same street, had varied opinions on the implementation of the rain gardens. What this report hopes to shed some light on is *why* some residents fully supported the rain gardens while others opposed them. Here, we study the degree to which being (1) informed about the program, (2) involved in the planning process, and (3) knowledgeable about water quality problems affect support for rain gardens in the neighborhood of Clintonville. We use data from a survey of 371 residents and find that feeling informed, involved, and being knowledgeable about local water quality problems are all associated with higher levels of support for rain gardens and analyze these factors' importance in the overall public planning process.

Context of Study: Blueprint Columbus

The context this study is operating in is within the solution to the crumbling sewer infrastructure that is causing massive problems to the city of Columbus. The over 5,000 miles of pipe that sit underground and are responsible for transporting residential and industrial waste and rainwater to water treatment plants or rivers ("Understanding Our Sewer System," 2019). When these pipes get overloaded it causes problems that not only affect residents but also the ecology of the rivers downstream, specifically pollution where storm sewers converge and dump into the river. Due to the fact that there is no treatment, the storm sewers carry with them excess nutrients such as fertilizers, heavy metals, construction debris, and trash (Brombach, Weiss & Fuchs, 2005).

This flooding of Columbus sewer systems remained a problem even after the Ohio Environmental Protection Agency (Ohio EPA) was forced to intervene and entered into two different consent orders with the city in 2002 and 2004 (City of Columbus, 2015). The 2002 consent order was directed at managing the sanitary sewer overflows (SSOs) and sewage backups into basements (water in basements, WIBs), and it called for the city to submit a System Evaluation and Capacity Assurance Plan (SECAP) (City of Columbus, 2015). The 2004 consent order was directed at managing combined sewer overflows (CSOs), and instructed the city to submit a Long Term Control Plan (LTCP) (City of Columbus, 2015). In 2005 the city of Columbus submitted the Wet Water Management Plan (WWMP), which included both the SECAP and LTC (City of Columbus, 2015). To present, the WWMP has spent over a billion dollars attempting to fix these drainage issues (City of Columbus, 2015). It was from this WWMP that Blueprint Columbus was created in 2012 (City of Columbus, 2015).

Blueprint Columbus is an integrated plan which has the same goal as the WWMP, to reduce the stormwater pollution concerns, but attempts to accomplish it by tackling a different part of the problem. The original WWMP is focused on the transport and treatment of the stormwater inflow and infiltration (I/I), while the Blueprint Columbus approach is to try to limit as much I/I from entering the sanitary sewer system in the first place (City of Columbus, 2015). Mayor Michael B. Coleman says that compared to the original WWMP, Blueprint Columbus is, “greener… more affordable… more innovative… better for our neighborhoods and our local economy… and is what the community wants” (City of Columbus, 2015, p.4). There are four different methods which Blueprint Columbus is utilizing to reach their requirements set by the Ohio EPA. The first three, lateral lining, roof water redirection, and a voluntary sump pump program are preventative in keeping stormwater out of the sanitary sewers (“Four Pillars,” 2019). The fourth method, green infrastructure, is integrated to filter and clean the rainwater runoff and slowly release it into a specific storm sewer system (“Four Pillars,” 2019).

The infrastructure of the storm and sanitary sewers can be categorized into two different groups: gray and green infrastructure. Two examples of gray infrastructure within the sewer system are the curb inlets and underground pipes ("Green Infrastructure Brochure," 2019). An example of green infrastructure within the sewer system would be either rain gardens or porous pavement ("Green Infrastructure Brochure," 2019). According to Obropta, DiNario, and Rusicano, "A rain garden is a shallow landscaped depression that is designed to capture, treat, and infiltrate stormwater runoff" (2008). Ideally, a rain garden is planted with species native to the region to increase positive environmental impacts. The focus of this report hereon will be rain gardens and the implementation process used by Blueprint Columbus, and how the research question interplays with the success and failures of the project.

When construction of the rain gardens began in Clintonville, there was a range of reactions from its residents. Leaders of the project had anticipated support for green infrastructure due to the fact that it was an environmentally conscious choice, cheaper than the other options, and had benefits for residents. Instead, residents voiced negative opinions about the location, design, and maintenance, of rain gardens in addition to other issues. The public relations specialist for the Clintonville rain gardens, Leslie Westefelt, had this to say about why the rain gardens seemed so controversial, "Rain gardens are located in the public right of way but in areas that many residents regard as their property," and added, "we should have done a better job explaining what this was" (Parks, 2018).

There are many misconceptions surrounding rain gardens. One common worry for adopters of rain gardens are mosquitos, and residents fear that these areas will be a perfect breeding ground for them (Everett, 2017). However, if the rain gardens are designed correctly and drain affectively, it will prevent stagnant water (Traver, 2009). Thus, properly designed rain gardens will not create a suitable breeding ground for mosquitos (Traver, 2009). Even though this is fact, perception of the rain gardens is still vital because it can impact several neighborhood factors from how developers plan future neighborhoods to homebuyer preferences (Everett, 2017).

What this study operating within this context hopes to reveal is, as discussed in the introduction, it is known that informing residents, getting them involved, and a higher knowledge base of water quality problems all lead to increased support for rain gardens; however, due to the fact that projects don't have unlimited budgets, it is important to see how each of the variables impact the levels of support for rain gardens *in Columbus*. This will allow planners to target specific variables and save time and money, while still accomplishing a better result.

Methodology

A.) Study Site

This study was conducted in six sections of Clintonville bordered by Morse Rd. to the north, Indianola Ave. to the East, High St. to the West, and Glencoe Rd. to the South (see Figure 1). The six neighborhoods were identified by the city of Columbus for the first phase of the Blueprint Columbus green infrastructure program.

B.) Data Collection

The data used in this study was collected using a survey that was distributed between August 2016 and May 2017. The survey was designed to collect, among other items, baseline data on knowledge and perceptions of the Blueprint Columbus program, knowledge of water quality problems, water use behaviors, and information on social interactions and physical activity.

Surveys were pre-tested with members of the general public and with graduate students and faculty affiliated with the Environmental and Social Sustainability Lab in the School of

Environment and Natural Resources. The pre-testing resulted in modifications to questions and the overall length of the survey.

The survey was mailed to a random selection of between 192 and 300 households per neighborhood, depending on the number of households located in a particular section of the neighborhood (see Table 7). Mailing addresses were collected from the Franklin County Auditor's website: http://property.franklincountyauditor.com/_web/maps/mapadv.aspx. Names and addresses were hand-written on labels that were then affixed to envelopes containing the surveys.

At least three weeks after mailing surveys, researchers visited households that had not yet returned a survey. Research assistants asked if residents had received a survey, if they still had a copy (and if not, whether they wanted a new one), and encouraged residents to respond. Residents were also reminded that they could enter a lottery for a $100 cash prize. If face-to-face interaction did not occur, research assistants were instructed to leave a copy of the survey on the doorstep as a reminder.

To see the demographic characteristics of the survey respondents please refer to Table 8 in the appendix.

C.) Key Variables

Dependent Variable:

The dependent variable for this study is residents' levels of support for rain gardens, which are an integral part of Blueprint Columbus. Our measure of support comes from three questions of support that were part of the survey. Residents were to respond on a Likert scale of 1 to 5, 1= strongly disagree and 5= strongly agree. The three questions are as follows:

1) Rain gardens installed and maintained by the city of Columbus would increase the value of my property.
2) Rain gardens would not improve the appearance of my neighborhood. (Reverse Coded).

3) I would like it if the city of Columbus installed rain gardens in front of my property.

Due to the fact there is relatively high correlation (using Pearson's R) between all three statements (see table below), we decided to sum them up to create an index of overall support for rain gardens, where high values = high support and low values = low support.

Table 1. Levels of correlation between the different statements

Correlation	Pearson's R
Between 1 & 2	r = 0.68
Between 1 & 3	r = 0.80
Between 2 & 3	r = 0.75

Below, is a table summarizing the range, mean, and standard deviation for each measure as well as the summed index for rain garden support, which is the dependent variable used in the study.

Table 2. Descriptive statistics for the three measures of support for rain gardens as well as the combined index of support

Measures of Support	Range	Mean	Standard Deviation
1) Rain gardens installed and maintained by the city of Columbus would increase the value of my property	1 to 5	2.87	1.30
2) Rain gardens would **not** improve the appearance of my neighborhood. (reverse coded)	1 to 5	3.02	1.36
3) I would like it if the city of Columbus installed rain gardens in front of my property.	1 to 5	2.55	1.46
Index of Rain Garden Support	3 to 15	8.32	3.78

Independent Variables:

There are three different independent variables that were identified throughout the study: how informed were residents by the city of Columbus, how involved were they by the city of Columbus, and how knowledgeable are they of water quality problems. These three independent variables were synthesized from three different questions (seen in the table below, respectively). All three of these questions were to be answered on a Likert scale of 1 to 5, 1= strongly disagree and 5= strongly agree. Below is a table summarizing the range, mean, and standard deviation for each independent variable. In addition to these three independent variables, we controlled for the effect of respondents' age, gender, and levels of education.

Table 3. Descriptive statistics for the three independent variables

Independent Variable	Range	Mean	Standard Deviation
The city of Columbus did enough to inform me about rain gardens and where they would be installed.	1 to 5	2.58	1.91
The city did enough to involve me in the decision to select where rain gardens would be installed.	1 to 5	1.27	0.97
Most natural waterways in and around Columbus (rivers, creeks, and streams) have water quality problems as a result of runoff after rainstorms.	1 to 5	3.99	0.79

<u>Analysis and Results</u>

A.) Regressions

A separate linear regression model was fit for each of the three independent variables. Below are the regression result tables.

Table 4. Estimates, standard errors and significance levels from the regression model for *Informed*

Coefficients:	Estimate	Std. Error	Pr(>|t|)	Signif. Code
(Intercept)	10.90476	1.93901	5.56e-08	***
City.Informed	0.71627	0.1844	0.000135	***
Age	-0.07133	0.01657	2.50e-05	***
Gender	-0.37764	0.44589	0.397943	
Education	0.62803	0.3036	0.039735	*
Income	-0.37291	0.12564	0.003324	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
N= 229
Degrees of Freedom: 228

Table 5. Estimates, standard errors and significance levels from the regression model for *Involved*

Coefficients:	Estimate	Std. Error	Pr(>|t|)	Signif. Code
(Intercept)	10.29895	1.85555	7.89e-08	***
City.Involved	1.15506	0.22648	7.14e-07	***
Age	-0.06722	0.01589	3.39e-05	***
Gender	-0.43883	0.42684	0.304990	
Education	0.68948	0.29387	0.019822	*
Income	-0.42036	0.11999	0.000553	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
N= 234
Degrees of Freedom: 233

Table 6. Estimates, standard errors and significance levels from the regression model for *Knowledge*

Coefficients:	Estimate	Std. Error	Pr(>|t|)	Signif. Code
(Intercept)	6.70550	1.94392	0.000663	***
Knowledge.WQ	1.27792	0.26582	2.7e-06	***
Age	-0.05377	0.01525	0.000505	***
Gender	-0.42732	0.42003	0.310013	
Education	0.60796	0.26669	0.023505	*
Income	-0.36936	0.11606	0.001653	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
N= 241
Degrees of Freedom: 240

B.) Key Findings

The results of our regression models indicate that there is a positive and statistically significant association between how informed residents felt they were from the city of Columbus and support for rain gardens (β=0.72, $p < 0.000$), even after controlling for age, gender, education and income. The results suggest that for every increase in agreement with the question indicating the resident felt informed by the city of Columbus, there is a 0.71 unit increase in support for rain gardens. That is, if we compared two women of the same age, education and income, the woman who strongly agreed that she felt informed from the city of Columbus would express a level of support for rain gardens that was a little under 3 points (0.71*4= 2.84) higher than the woman who strongly disagreed that she felt informed by the city of Columbus.

The results of our regression model also indicate that there is a positive and statistically significant association between how involved residents were by the city of Columbus and support for rain gardens (β=1.16, $p < 0.000$), even after controlling for age, gender, education and income. The regression results suggest that for every increase in agreement with the question indicating that resident felt involved by the city of Columbus, there is a 1.15 unit increase in support for rain gardens. That is, if we compared two women of the same age, education and income, the woman who strongly agreed that she felt involved from the city of Columbus would express a level of support for rain gardens that was a little more than four and a half points (1.15*4= 4.6) higher than the woman who strongly disagreed that there are water quality problems.

Similarly, the results of our regression model indicate that there is a positive and statistically significant association between how knowledgeable residents were about water quality issues in the area and support for rain gardens (β=1.28, $p < 0.000$), even after controlling for age, gender, education and income. The regression results suggest that for every increase in agreement with the question indicating that there are water quality problems in most of Ohio's rivers, there is a 1.27 unit increase in support for rain gardens. That is, if we compared two women of the same age, education and income, the woman who strongly agreed that there are water quality problems would express a level of support for rain gardens that was five points (1.27*4= 5.1) higher than the woman who strongly disagreed that there are water quality problems. As shown by our results, knowledge level has the biggest effect on support levels out of all the independent variables.

An interesting finding in the regression results has to do with age. For all three variables, there was a negative and statistically significant association between age and support for rain gardens (β= -0.07, -0.07, -0.05, all with $p < 0.000$). These regression results suggest that for every year increase in age, there is a 0.05 to 0.07 unit decrease in support for the rain gardens. For example, if we had two homeowners, one 30 years old and one 60 years old, the 60 year old would likely support the rain gardens from two to under three points less (0.05 x 40= 2 and 0.07 x 40= 2.8) than the 30 year old homeowner.

The final finding presents itself when looking at the plot of distribution of the levels of support (See Figure 3). For the most part, it looks bell-shaped, with the exception of those who had a support level of 3 (the lowest level of support). Since these 59 respondents became of interest, we created a demographics table for these 59 (Table 9) and the other 385 respondents who had support levels from 4-15 (Table 10), in order to see what was different about these 59 respondents. The strongest characteristic that those who had the lowest level of support is that half (50.8%) of them were 60 years old and older, and the majority (80.3%) of respondents were at least 45 years old. This makes sense considering the above negative association between age and the fact that older people are more likely to hold traditional values and have less mobility to maintain raingardens, therefore their support for the implementation is likely to be the lowest out of all the age groups (Wiliker et al., 2016).

Discussion

Looking at the results above, all three independent variables (*informed, involved,* and *knowledge)* are positively and significantly associated with higher levels of support for rain gardens in Columbus, OH. These results are similar to those from studies conducted in other areas. For example, in one of the six case studies performed in Wiliker et al.'s (2016) research, participants from Manchester, UK had a very high level of support for a GI project because they were so heavily involved in the planning and implementation processes. Baptiste et al. (2015) found a positive correlation between levels of knowledge of environmental and water quality issues and participants levels of support and willingness to implement GI in their own neighborhoods and yards.

Regarding the *informed* variable, Arnstein states that informing the citizens is the first step towards participation. However, if information flows from the top-down or only flows in one direction, then residents may feel less involved and in turn have a lower level of support for projects (Arnstein, 1969). As seen in Columbus, the information largely flowed from the city downward. So even though, on average, residents felt more informed than involved by the city, because being involved is located higher up on the Arnstein ladder, involvement has a higher degree of citizen power (Arnstein, 1969). This increase in citizen power translates to higher support because it causes citizens feel more invested and more likely to offer suggestions, because they feel their voices are being heard by project coordinators (Arnstein, 1969). It's this effect that helps explain why the *informed* variable had the lowest positive association in this context.

As an example of how additional information and public involvement could have improved support for Blueprint Columbus, comes from residents' concerns about where rain gardens were being constructed. Many residents were unaware of the technical process involved in siting the rain gardens. Some residents complained that rain gardens should be located in front of the homes of people who wanted them and away from the homes of people who did not. However, the location of the rain garden was largely determined by (1) hydrological models the indicated the direction of water flow and ideal locations for the gardens and (2) the location of driveways and underground utilities that prevent the placement of a rain garden. This is one example of how additional information and public involvement may have reduced some concerns about the rain gardens. Lastly, it is important to note the structural component of GI. Due to the hydrological models and the location of underground utilities, much of the design and planning process had to be completed prior to involving the residents because of the restrictions on where the rain gardens could and could not be sited. These caveats are important, however with more research, more ways to overcome these hurdles will be uncovered.

Although these variables seem like they would be common sense to target, the real world is not as black and white as this paper. Generating high levels of local participation and involvement requires additional costs and time. The implementing agencies must use employee time and energy to plan, organize and run outreach and engagement programs. Obtaining and using public input in the planning process can extend the time that it takes to finalize project details. Obtaining public input and participation also requires a proportion of residents who are willing and able to devote time to engagement programs and public feedback sessions. Even if these costs can be managed, and residents are engaged, this does not guarantee long-term gains in local support.

Limitations and Future Research

An important fact to note is that although this study analyzed these three variables separately, the reality is that they are all engrained within each other. Knowledge, information, and involvement increase support of GI's. Yet, knowledge might also increase involvement and being involved may lead residents to have an even greater knowledge of water quality problems and why it is important to fix them. As information increases knowledge and involvement, involvement also increases information as a direct line of communication is opened, and in turn knowledge of issues blossoms. All of these variables contribute to each other, and that should not be ignored. Therefore, future analyses could explore potential interaction effects among these variables.

One of the most important limitations to note is the fact that even though this survey had a relatively high response rate, it is not a perfect representation of the demographics of Clintonville as a whole (See Table 8). When compared to data from the Census Bureau (2017) in Table 11 in the Appendix, it appears that the survey has oversampled older, wealthier, and more educated individuals of Clintonville. The median age in the census data is 42.8 and the median age in the survey responses is 62 years old. Also, the median household income in the census data is $73,560, whereas in the survey data, the median household income is in the $80,000-$99,999 category. Lastly, even though the number of residents that had their bachelor's degree is similar in both the census and survey data, the amount of graduate school and/or graduate degrees was far higher in the survey data. That being said, when looking at the data more in depth, there is no tendency for the older groups of those surveyed to feel less involved, informed, or knowledgeable about the topic than any of the other age groups. The same also follows for the categories of education and household income. So, despite the sample not being representative of the general demographic profile of Clintonville, we still have confidence that there is an important relationship between involvement, knowledge and degree of support for Blueprint Columbus.

Another limitation of this study is the fact the timeline of this project focuses on the design and implementation aspects of GI projects, as the survey was sent out *prior* to the installation of the rain gardens. Other studies, for example Wiliker et al's 2016 work, note the importance of continued support to keep GI operating and being as efficient as possible. This leaves room for expansion on this study to resurvey these neighborhoods in a few years and evaluate resident's levels of support after they have had time to properly interact with the rain gardens.

Another limitation of the study is that the survey wasn't created solely for this research. Therefore, we had to develop a way to measure the level of support without explicitly asking the residents what they would rank their level of support as. The "Index of Rain Garden Support" could add a slight bias in the data; however, we still believe that the Index is still representative of the survey population's actual level of support.

Lastly, because this report focuses on factors that affect support, a lot of the overall barriers to implementation were overlooked due to relevance. Just as this study was context dependent, so are the barriers to implementing GI. More research can be done, specifically in Columbus, Ohio, to ascertain which of the concerns about GI (i.e. mosquito misconceptions, safety, aesthetics, trust in the city to maintain, etc.) have the most effect on the residents' opinions of rain gardens. The resulting research combined with this study could be used to create a comprehensive profile used to help with the implementation of rain gardens in other nearby neighborhoods to increase efficiency, save on costs and time, as well as being able to pick the best target audience who are the most willing to adopt, maintain, and be involved in the Blueprint Columbus project.

Conclusion

The goal of this study was to identify the factors that had the most influence on the residents' levels of support for rain garden implementation. The three factors that were observed were being (1) informed about the program, (2) involved in the planning process, and (3) knowledgeable about water quality problems. Of the three variables, *knowledge* had the largest impact on support levels, followed by *involvement*, and *informed*. There was also a negative association found between age and support for rain gardens. What this study shows is what the city of Columbus can do moving forward to garner greater support. By informing and involving residents early in the project process and providing better information about water quality problems that justified Blueprint Columbus, they can help to ensure a smoother implementation process that allows rain gardens and the residents of Columbus to thrive together.

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Appendix

Figure 1: The Eight Rungs on the Ladder of Citizen Participation (Arnstein, 1969)

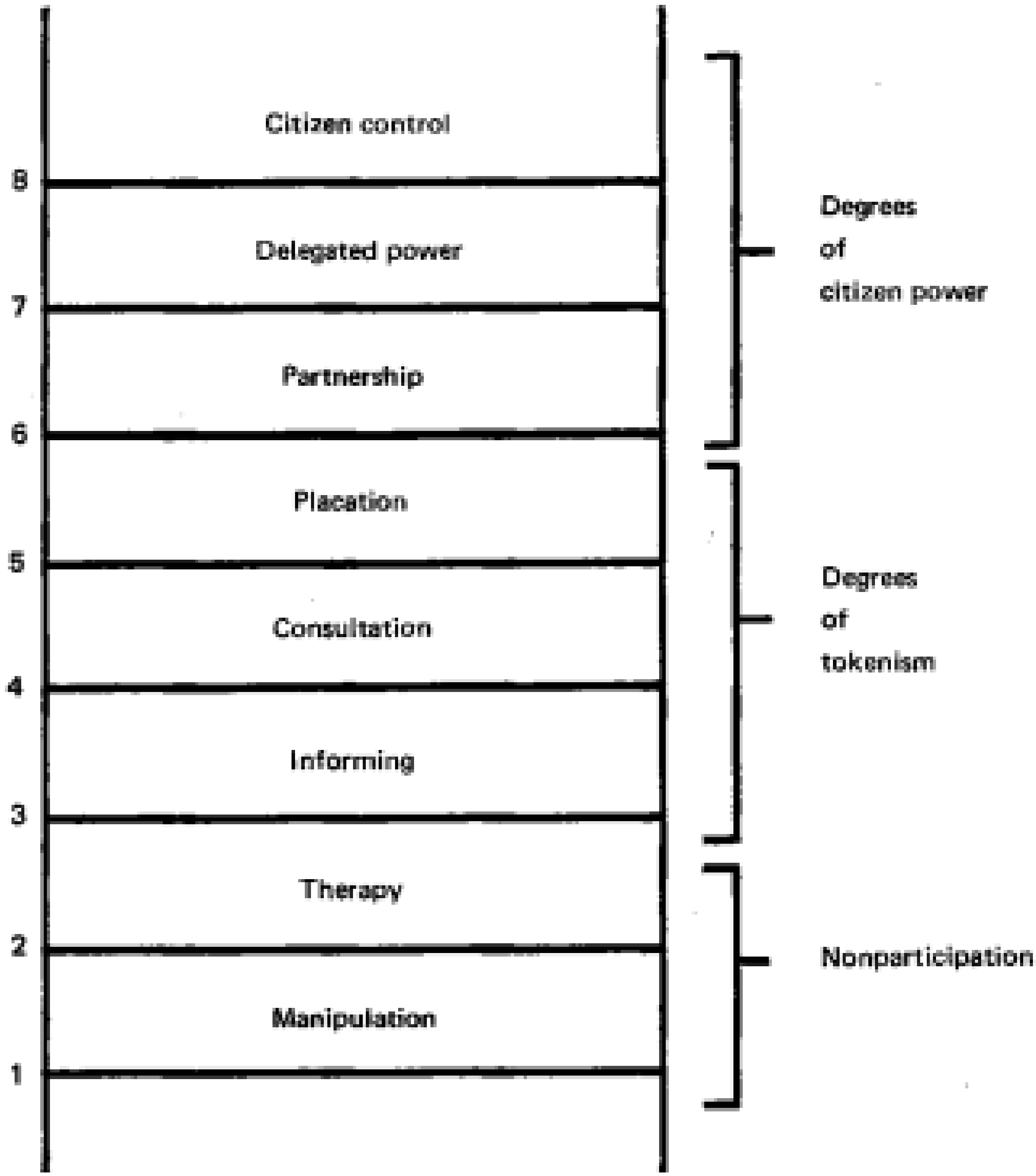

Figure 2: Map of Blueprint Columbus Potential Green Infrastructure Locations

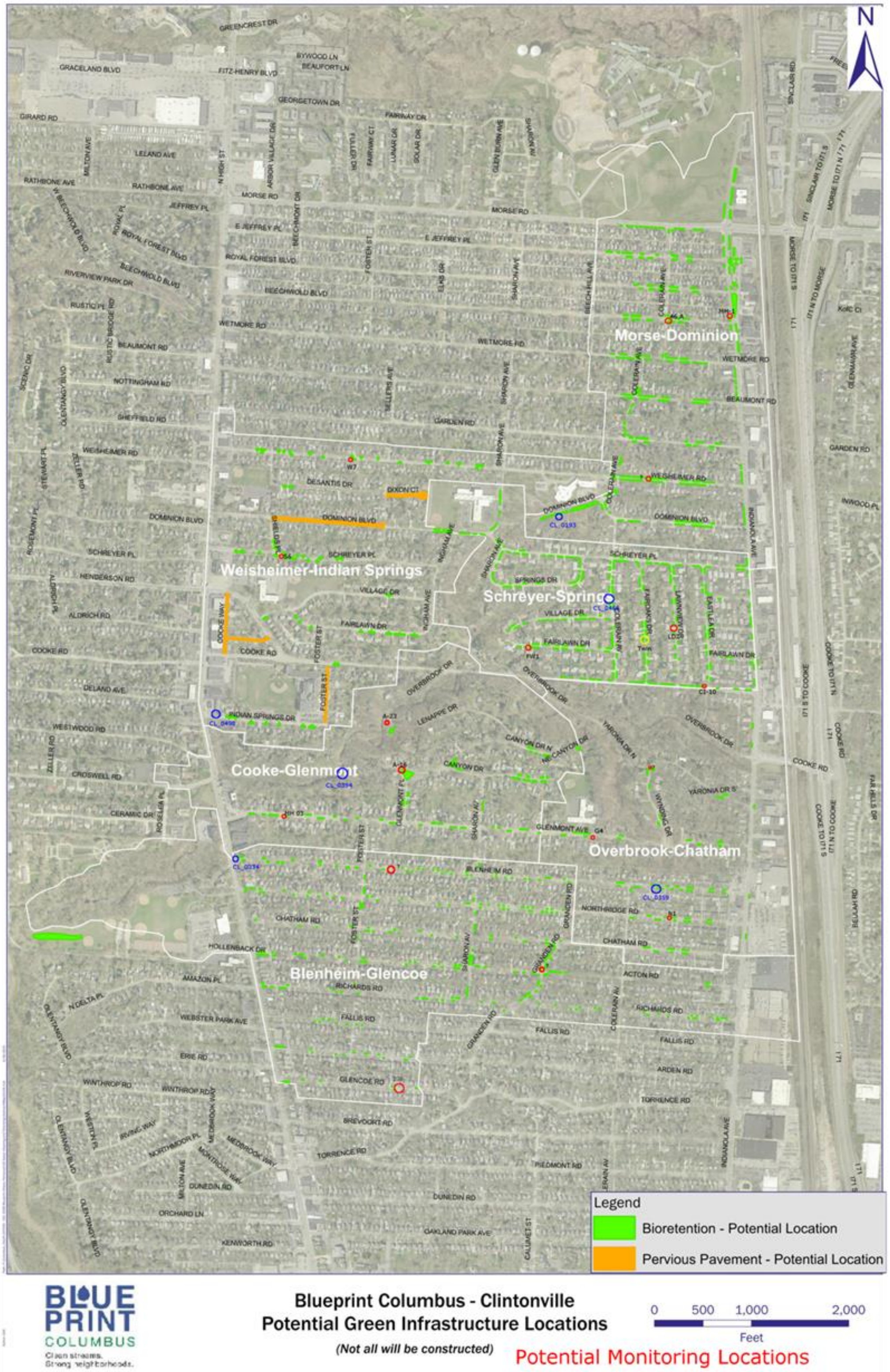

Table 7: Survey Response Rates

Neighborhood	Surveys Mailed	Surveys Returned	Response Rate
Cooke	300	85	28%
Blenheim	252	78	31%
Schreyer	192	79	41%
Weisheimer	261	72	28%
Morse	261	68	26%
Overbrook	261	70	27%

Table 8: Demographic Characteristics of Survey Respondents

	Responses	*Response Count*	Response %
Sex			
	Male	177	40.0%
	Female	244	55.1%
	Other	3	0.7%
	N/A	19	4.3%
Age			
	18-30 years	7	1.6%
	31-45 years	75	17.2%
	46-60 years	104	23.8%
	61 years and over	225	51.5%
	N/A	26	5.9%
Education			
	No diploma	2	0.5%
	High school diploma	22	5.0%
	Some college, or associate's degree	52	11.7%
	Bachelor's degree	160	36.0%
	Some graduate school or graduate degree	193	43.5%
	N/A	15	3.4%
Household's approximate total annual income (before taxes)			
	I don't know	12	2.7%
	No Income	1	0.2%
	<$20,000	13	2.9%
	$20-39,999	28	6.3%
	$40-59,999	43	9.7%
	$60-79,999	68	15.4%
	$80-99,999	48	10.9%
	$100-119,999	53	12.0%
	$120-139,999	31	7.0%
	>$140,000	78	17.6%
	N/A	67	15.2%

Figure 3: Distribution of Support for Rain Gardens in Clintonville, Ohio

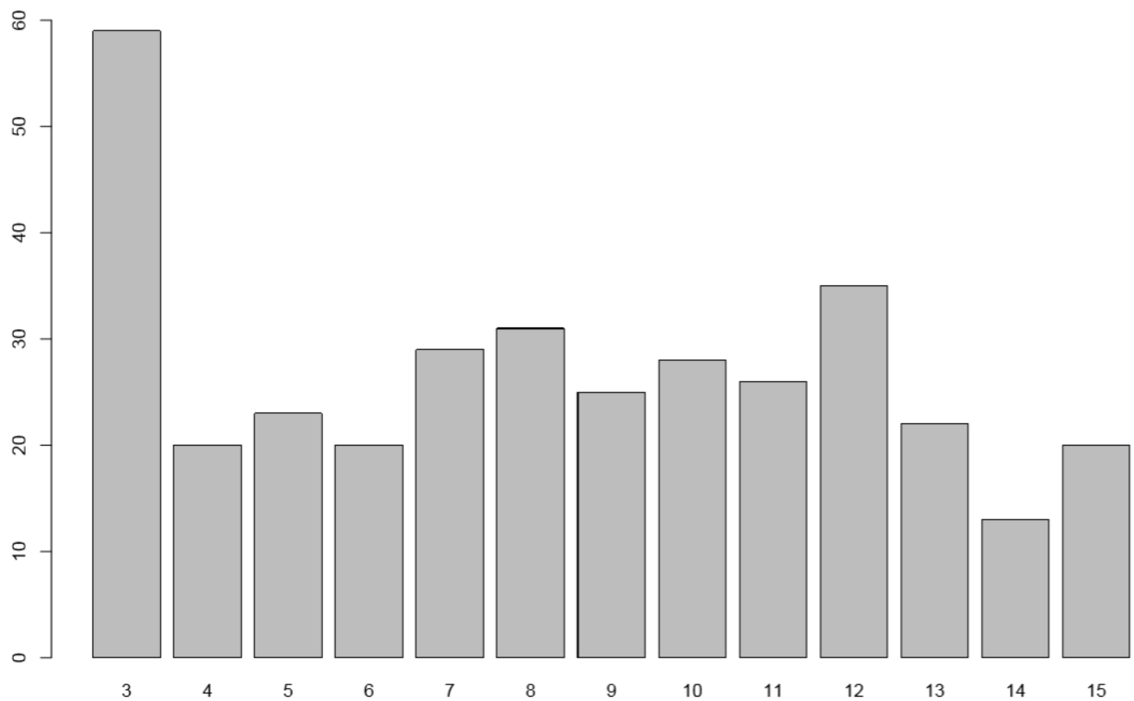

Table 9: Demographic Characteristics of Survey Respondents that had a Support Level of 3

	Responses	***Response # N=59***	***Response %***
Sex			
	Female	27	45.8%
	Male	28	47.5%
	N/A	4	6.8%
Age			
	18-30	0	0.0%
	31-45	6	10.2%
	46-60	18	30.5%
	61 years and older	30	50.8%
	N/A	5	8.5%
Education			
	No diploma	0	0.0%
	High school diploma	4	6.8%
	Some college, or associate's degree	10	16.9%
	Bachelor's degree	26	44.1%
	Some graduate school or graduate degree	17	28.8%
	N/A	2	3.4%
Household's approximate total annual income (before taxes)			
	I don't know	5	8.5%
	No Income	0	0.0%
	<$20,000	2	3.4%
	$20-39,999	3	5.1%
	$40-59,999	2	3.4%
	$60-79,999	5	8.5%
	$80-99,999	4	6.8%
	$100-119,999	8	13.6%
	$120-139,999	2	3.4%
	>$140,000	11	18.6%
	N/A	17	28.8%

Table 10: Demographic Characteristics of Survey Respondents that had a Support Level from 4 to 15

	Responses	***Response # N= 385***	***Response %***
Sex			
	Female	217	56.4%
	Male	149	38.7%
	Other	3	0.8%
	N/A	16	4.2%
Age			
	18-30	7	1.8%
	31-45	70	18.2%
	46-60	89	23.1%
	61 years and older	195	50.6%
	N/A	24	6.2%
Education			
	No diploma	2	0.5%
	High school diploma	18	4.7%
	Some college, or associate's degree	42	10.9%
	Bachelor's degree	134	34.8%
	Some graduate school or graduate degree	176	45.7%
	N/A	13	3.4%
Household's approximate total annual income (before taxes)			
	I don't know	7	1.8%
	No Income	1	0.3%
	<$20,000	11	2.9%
	$20-39,999	25	6.5%
	$40-59,999	42	10.9%
	$60-79,999	63	16.4%
	$80-99,999	44	11.4%
	$100-119,999	45	11.7%
	$120-139,999	29	7.5%
	>$140,000	67	17.4%
	N/A	51	13.2%

Table 11: Census Demographics of Residents within Clintonville Surveyed Area

Census Category	
Median Age	42.8
Education:	
No diploma	2.50%
High school diploma	10.3%
Some college, or associate's degree	26.30%
Bachelor's degree	36.70%
Some graduate school or graduate degree	24.20%
Median Household Income	$73,560